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Mopeds — Measurement method for location of centre of gravity

Cyclomoteurs — Méthode de mesure de l'emplacement du centre de gravité

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 8705 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 23, *Mopeds*.

This second edition cancels and replaces the first edition (ISO 8705:1991) which has been technically revised.

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Introduction

The stability of a moped is a very important element of its active safety. The moped/rider combination and the environment in which this combination is used form a unique closed-loop system. However, the evaluation of the moped/rider combination stability is extremely complex because of interaction of the intrinsic moped stability, the influence of position of the rider and his response to continuously changing conditions.

In the evaluation of moped stability, the determination of the kinetic characteristics of the moped/rider combination is considered an important part of the design parameters of the vehicle itself.

The test procedure described in this International Standard deals with one aspect of the kinetic characteristics: the determination of the centre of gravity of the moped and of the moped/rider combination.

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Mopeds — Measurement method for location of centre of gravity

1 Scope

This International Standard specifies a measuring method for determining the location of the centre of gravity of the moped and of the moped/rider combination. It applies to two-wheeled mopeds.

Other measuring methods can be used if it is demonstrated that the results are equivalent.

The measuring results obtained by the method given in this International Standard alone (see Annex A) cannot be used for an evaluation of the vehicle stability because they deal with only one aspect of this very complex phenomenon.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3779, *Road vehicles — Vehicle identification number (VIN) — Content and structure*

49 CFR Part 572, subpart B [*Code of Federal Regulations,* issued by the National Highway Traffic Safety Administration (NHTSA)]

3 Definitions of axis systems

3.1 The moped axis system (x, y, z) is a right-hand orthogonal axis system fixed in the moped such that when the moped is moving in a straight line on a level road, the x-axis is substantially horizontal, points forwards and is in the longitudinal plane of symmetry. The y-axis points to the rider's left side and the z-axis points upwards. This coordinate system applies to translation motion and rotational motion together with the moped.

Assuming that the moped is fixed to the platform, the coordinate system is also applied to the platform.

3.2 The Earth-fixed axis system (X, Y, Z) is a right-hand orthogonal axis system fixed on the Earth. The X- and Y-axes are in a horizontal plane and the Z-axis points upwards.

4 Measurement conditions

4.1 Measurement conditions for a moped shall be as follows:

a) the moped shall be free from mud and deformation, and operate normally;

b) the fuel shall be filled up to the top level specified in the operation manual;

c) lubricating oil and cooling water shall be filled up to the level specified in the operation manual;

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d) tyre pressure shall be as specified in the operation manual;

e) tools shall be provided at the regular storage positions;

f) front and rear suspension systems shall be fixed at a static position;

g) the front wheel shall be positioned along the x-axis.

If the conditions are to be modified according to the object of the measurement, the modified conditions shall be recorded in the measurement report.

4.2 Measurement conditions when a rider is on the moped shall be as follows:

a) measurement conditions of the moped shall be as set forth as in 4.1;

b) a test dummy [1)] having a mass of 73,4 kg, or an equivalent man, shall be used as the rider;

c) the rider shall be positioned as follows:

1) the rider shall be positioned on the vertical centre surface of the moped;

2) the rider shall sit on the seat, hold the handle bar by both hands, and place both feet on the foot rests;

3) obtain the angle formed by the line connecting the point S [2)] and point H [3)] and the x-axis; that angle shall be the angle of the rider's posture;

4) obtain the distance between the front axle and the point H along the x-axis, that distance shall be the seating position of the rider.

However, if the conditions are to be modified according to the object of measurement, the modified conditions shall be recorded in the measurement report.

5 Measuring instruments (apparatus)

Measuring instruments to measure the centre of gravity shall be as follows or having equivalent functions and accuracy.

5.1 **precision square level**, that can measure up to 0,1 mm/1 m.

5.2 **steel tape measure**, with a tolerance of $\pm$ [0,3 + 0,1(L − 1)] mm at a length, L expressed in metres.

5.3 **angle gauge**, that can measure the rotational angle to 0,1° electrically or mechanically.

5.4 **weighing scales**, with enough accuracy to weigh the object to 0,1 kg.

5.5 **support**, used when placing the platform on the weighing scale.

5.6 **platform**, with the highest possible rigidity and of light weight.

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1) Test dummy as specified in 49 CFR Part 572, subpart B, or equivalent.

2) Point indicating the centre of rotation of the dorso and the arms of the rider.

3) Point indicating the centre of rotation of the dorso and femoral regions of the rider.

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5.7 **knife edge**, the roundness of which at the edge shall be below 1 mm in radius [4)].

NOTE An edge angle below 90° is recommended.

5.8 **weights**, to incline the platform.

6 Measuring procedure

6.1 Location of centre of gravity along x-axis

6.1.1 Location of centre of gravity of the empty platform along x-axis

Measure the location of the centre of gravity of the empty platform along the x-axis as follows (see Figure 1):

a) place supports (5.5) at the centres of the front and rear weighing scales and measure the respective loads, P_{KF} and P_{KR};

b) place the platform (5.6) on the two supports, such that its centre of gravity lies directly above the line connecting the two supports (the platform includes any brackets/wires necessary to hold the moped;

NOTE If it is difficult to locate the centre of gravity above the line connecting the two supports, use additional sets of a weighing scale and a support, such that the centre of gravity falls on the area framed by additional supports and the support F and R.

c) measure the distance, x_{PF}, along the x-axis from the point A at the front end of the platform to the support F on the front side and the distance, x_{PR}, along the x-axis from the point A to the support R on the rear side;

d) measure the loads, P_{FR} and P_{RR}, distributed to the front and rear supports;

e) calculate the distance x_P along the x-axis from the point A at the front end of the platform to the centre of gravity using the following equations:

$$P_{PF} = P_{FR} - P_{KF} \quad (1)$$

$$P_{PR} = P_{RR} - P_{KR} \quad (2)$$

$$x_P = \frac{x_{PF}P_{PF} + x_{PR}P_{PR}}{P_{PF} + P_{PR}} \quad (3)$$

where

P_{PF} is the load of the platform distributed to support F, in newtons;

P_{FR} is the total load given by the platform and the load given by support F distributed to support F, in newtons;

P_{KF} is the load of support F, in newtons;

P_{PR} is the load of the platform distributed to support R, in newtons;

P_{RR} is the total load given by the platform and the load given by support R distributed to support R, in newtons;

4) The roundness at the edge is the form of edge finished sharply when rounded with the load applied to it.

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P_{KR} is the load of support R, in newtons;

x_P is the distance from point A at the front end of the platform to the centre of gravity along the x-axis, in millimetres;

x_{PF} is the distance from point A at the front end of the platform to support F along the x-axis, in millimetres;

x_{PR} is the distance from point A at the front end of the platform to support R along the x-axis, in millimetres.

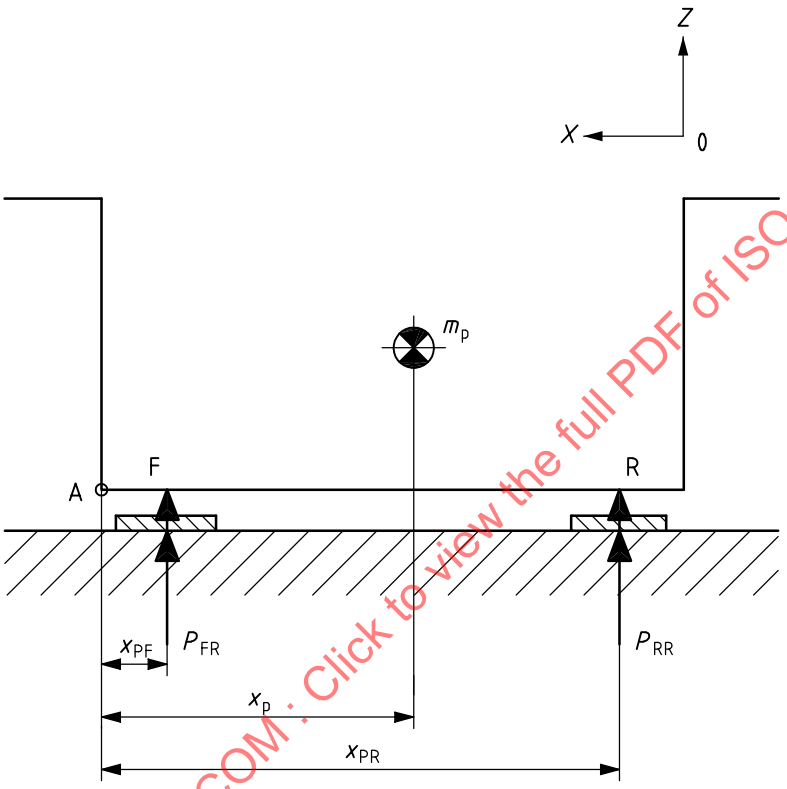

Figure 1 — Location of centre of gravity of the platform along the x-axis

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6.1.2 Location of centre of gravity of moped along the x-axis

Measure the location of the centre of gravity of the moped [5] along the x-axis as follows (see Figure 2):

a) place the moped on the platform, such that the tyre centrelines are parallel to and vertically above the line connecting the two supports and fix it so it cannot move, lateral inclination angle of the moped to the platform shall be 0° ± 0,5°;

b) measure the distance, x_F, along the x-axis from point A at the front end of the platform to the front axle of the moped;

c) measure the loads, P_{MF} and P_{MR}, distributed to the front and rear supports;

d) calculate the distance, x_g, along the x-axis from the front axle of the moped to the location of centre of gravity using the following equations:

5) The case here includes both cases of the moped without and the moped with a rider.

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$$m_m = m_T - m_P \quad (4)$$

$$P_{TF} = P_{MF} - P_{KF} \quad (5)$$

$$P_{TR} = P_{MR} - P_{KR} \quad (6)$$

$$x_T = \frac{x_{PF} P_{TF} + x_{PR} P_{TR}}{P_{TF} + P_{TR}} \quad (7)$$

$$x_m = \frac{x_T m_T - x_P m_P}{m_m} \quad (8)$$

$$x_g = x_m - x_F \quad (9)$$

where

m_m is the mass of the moped, in kilograms;

m_T is the total mass of the moped and platform, in kilograms;

m_P is the mass of the platform, in kilograms;

P_{TF} is the load of the platform and moped distributed to support F, in newtons;

P_{MF} is the total load given by the platform and moped, and the load given by support F distributed to support F, in newtons;

P_{TR} is the load of the platform and moped distributed to support R, in newtons;

P_{MR} is the total load given by the platform and moped, and the load given by support R distributed to support R, in newtons;

x_T is the distance from point A at the front end of the platform to the centre of gravity of both moped and platform along the x-axis, in millimetres;

x_m is the distance from point A at the front end of the platform to the centre of gravity of the moped along the x-axis, in millimetres;

x_g is the distance from the front axle of the moped to the centre of gravity along the x-axis, in millimetres;

x_F is the distance from point A at the front end of the platform to the front axle of the moped along the x-axis, in millimetres.

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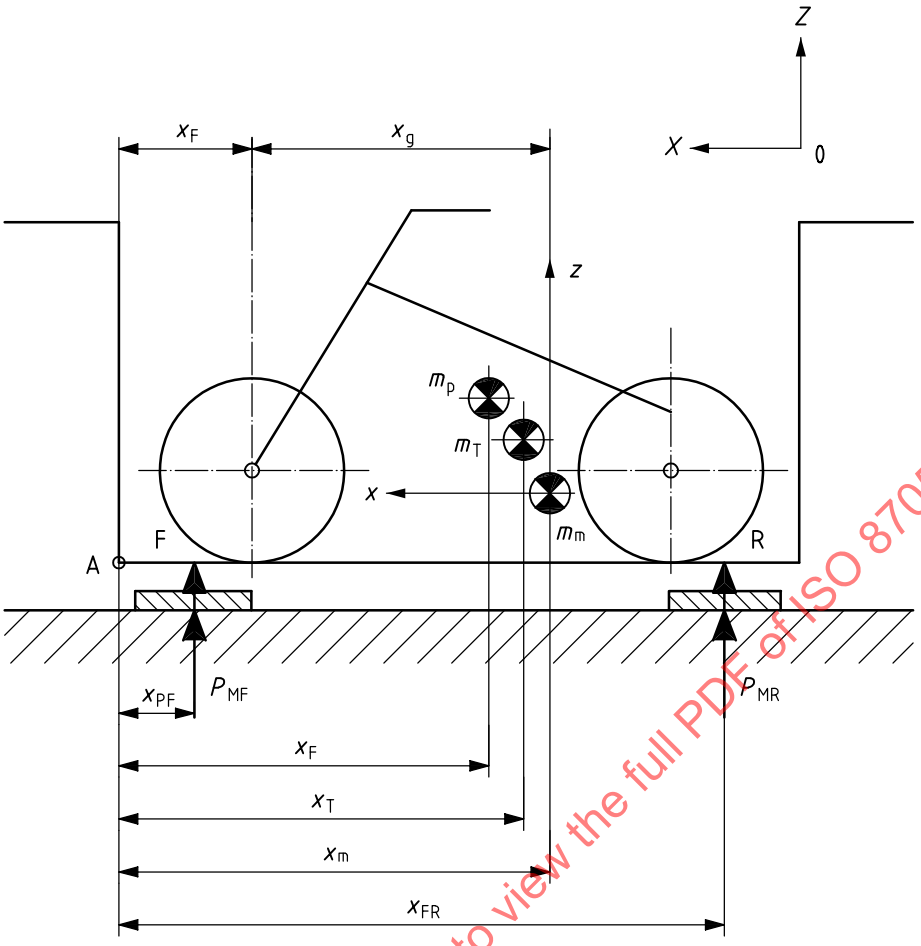

Figure 2 — Location of centre of gravity of the moped along x-axis

6.2 Location of centre of gravity along y-axis

6.2.1 Location of centre of gravity of the empty platform along y-axis

Measure the location of the centre of gravity of the empty platform along the y-axis as follows (see Figure 3):

a) place supports at the centres of the right and left weighing scales and measure the respective loads, P_{KL} and P_{KR};

b) place the platform on the two supports, such that its centre of gravity lies directly above the line connecting the two supports (the platform includes any brackets/wires necessary to hold the moped); if it is difficult to locate the centre of gravity above the line connecting the two supports, use additional sets of a weighing scale and a support, such that the centre of the gravity falls on the area framed by additional supports and supports F and R;

c) measure the distance, y_{PL}, along the y-axis from point B at the left end of the platform to support L on the left side and the distance, y_{PR}, along the y-axis from point B to support R on the right side;

d) measure the loads, P_L and P_R, distributed respectively to the left and right supports;

e) calculate the distance, y_P, along the y-axis from point B at the left end of the platform to the centre of gravity using the following equations:

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$$P_{PL} = P_L - P_{KL} \tag{10}$$

$$P_{PR} = P_R - P_{KR} \tag{11}$$

$$y_P = \frac{y_{PL}P_{PL} + y_{PR}P_{PR}}{P_{PL} + P_{PR}} \tag{12}$$

where

P_{PL} is the load of the platform distributed to support L in newtons;

P_L is the total of load given by the platform and the load given by support L distributed to support L in newtons;

P_{KL} is the load of support L in newtons;

P_{PR} is the load of the platform distributed to support R in newtons;

P_R is the total of load given by the platform and the load given by support R distributed to support R in newtons;

P_{KR} is the load of support R in newtons;

y_P is the distance from point B at the left end of the platform to the centre of gravity along the y-axis in millimetres;

y_{PL} is the distance from point B at the left end of the platform to the support L along the y-axis in millimetres;

y_{PR} is the distance from point B at the left end of the platform to the support R along the y-axis in millimetres.

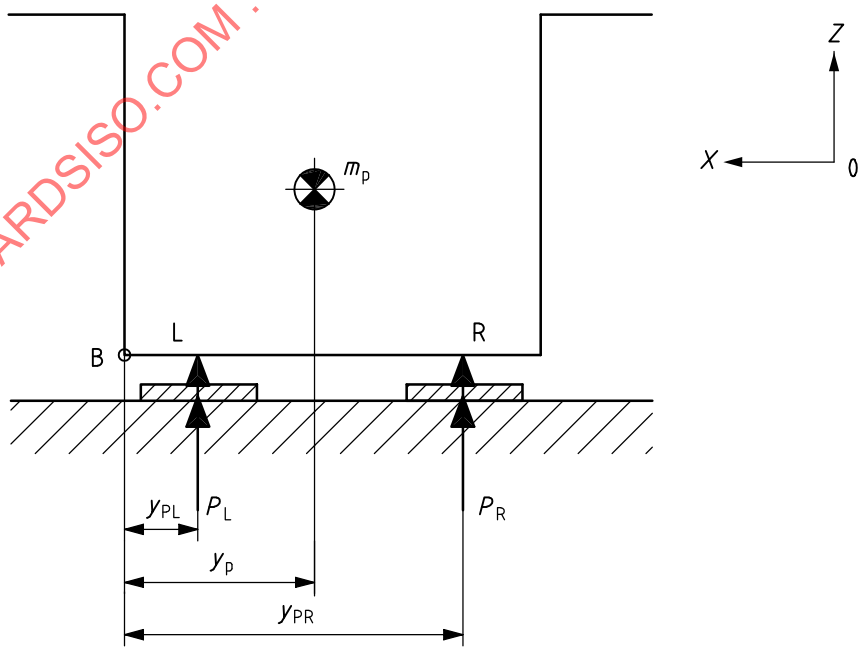

Figure 3 — Location of centre of gravity of the platform along y-axis

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6.2.2 Location of centre of gravity of moped along y-axis

Measure the location of the centre of gravity of the moped [5)] along the x-axis as follows (see Figure 4):

a) place the moped on the platform, such that the measured location of the centre of gravity along the moped x-axis is directly above the line connecting the two supports, and the tyre centrelines are perpendicular to the line connecting the two supports, and fix it so it cannot move, the lateral inclination angle of the moped to the platform shall be 0° ± 0,5°;

b) measure the distance, y_0, along the y-axis from point B at the left end of the platform to the vertical centre surface of the moped;

c) measure loads, P_{ML} and P_{MR}, distributed respectively to the left and right supports;

d) calculate the distance, y_g, along the y-axis from the vertical centre surface of the moped to the location of centre of gravity by the following equations:

$$m_m = m_T - m_P \tag{13}$$

$$P_{TL} = P_{ML} - P_{KL} \tag{14}$$

$$P_{TR} = P_{MR} - P_{KR} \tag{15}$$

$$y_T = \frac{y_{PL}P_{TL} + y_{PR}P_{TR}}{P_{TL} + P_{TR}} \tag{16}$$

$$y_m = \frac{y_T m_T - y_P m_P}{m_m} \tag{17}$$

$$y_g = y_0 - y_m \tag{18}$$

where

m_m is the mass of the moped, in kilograms;

m_T is the total mass of the moped and platform, in kilograms;

m_P is the mass of the platform, in kilograms;

P_{TL} is the load of the platform and moped distributed to support L, in newtons;

P_{ML} is the total of load given by the platform and moped, and the load given by support L distributed to support L, in newtons;

P_{TR} is the load of the platform and moped distributed to support R, in newtons;

P_{MR} is the total of load given by the platform and moped, and the load given by support R distributed to support R, in newtons;

y_T is the distance from point B at the left end of the platform to the centre of gravity of both moped and platform along the y-axis, in millimetres;

y_m is the distance from point B at the left end of the platform to the centre of gravity of the moped along the y-axis, in millimetres;

y_g is the distance from the vertical centre surface of the moped to the centre of gravity along the y-axis, in millimetres;

y_0 is the distance from point B at the left end of the platform to the vertical centre surface of the moped along the y-axis, in millimetres.

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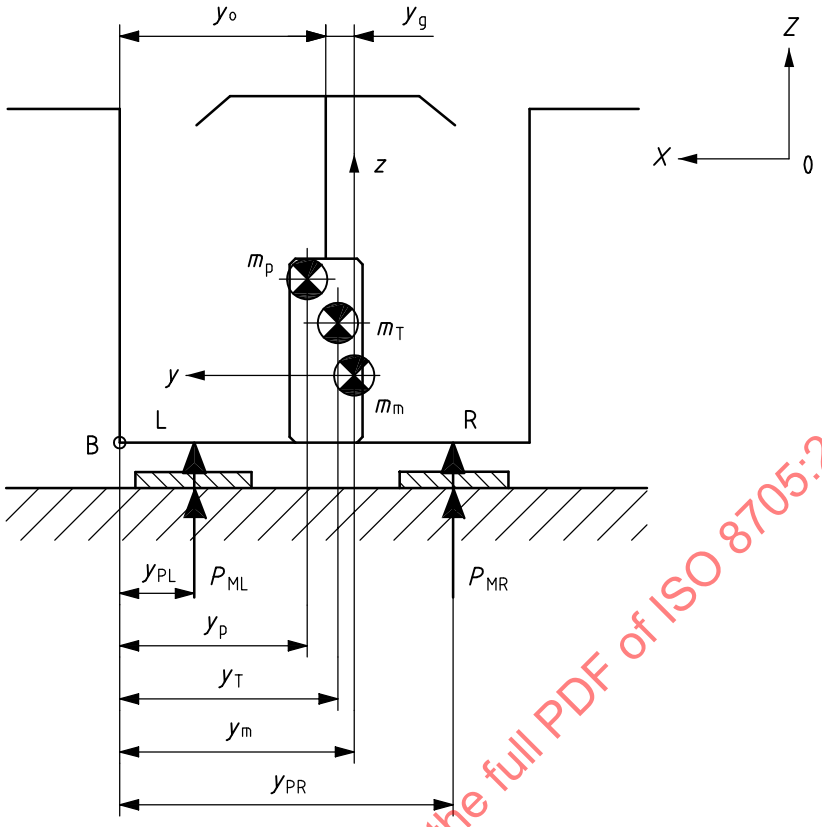

Figure 4 — Location of centre of gravity of the moped along y-axis

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6.3 Location of centre of gravity along z-axis

6.3.1 Location of centre of gravity of the empty platform along z-axis

Measure the location of the centre of gravity of the empty platform along the z-axis as follows (see Figures 5 and 6):

a) measure the distance, h_0, from the bottom surface of the platform on which the moped is to be placed against the knife edge (5.7) along the z-axis;

b) measure distances, a_0 and b_0, from the knife edge to point C at the position a weight (5.8) of mass m_{k1} is to be suspended along the x-axis and the z-axis, respectively;

c) place the platform on the knife edge of the stay and measure the angle θ_P formed by the platform bottom surface and the horizontal surface; at this time, the calculation equation for the location of centre of gravity as described in e) varies depending on the platform inclination direction;

d) suspend a weight of mass, m_{k1}, from point C of the platform so that the point C side of the platform is lower and measure the angle, θ_K, formed by the platform bottom surface and the horizontal surface [see Figures 5b) and 6b)]; as the inclination angle, θ_K, increases, the value of the location of centre of gravity along the z-axis becomes stable and the measurement error decreases.

NOTE It is recommended to incline it more than 10°.

e) calculate the distance z_P from the platform bottom surface to the centre of gravity along the z-axis using the following equations, for the $\pm$ symbols in the equation, use the negative if the point C side is lower when measuring θ_P [see Figure 5a)] and use the positive when the point C side is raised [see Figure 6a)]:

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$$c_P = \frac{m_{k1}\left(a_0 + b_0 \tan\theta_K\right)}{m_P\left(\tan\theta_K \pm \tan\theta_P\right)} \tag{19}$$

$$z_P = h_0 - c_P \tag{20}$$

where

c_P is the distance from the knife edge to the centre of gravity of the platform along the z-axis, in millimetres;

m_{k1} is the mass of weight suspended to the platform, in kilograms;

a_0 is the distance along the x-axis from the knife edge to point C suspending the weight, in millimetres;

b_0 is the distance along the z-axis from the knife edge to point C suspending the weight, in millimetres;

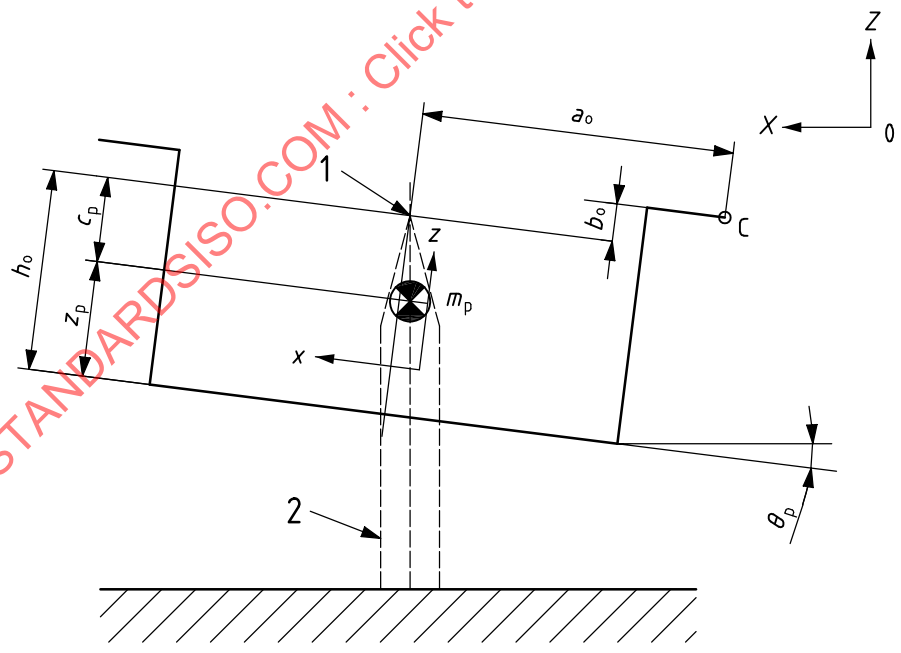
θ_K is the angle formed by the platform bottom surface and the horizontal surface with the platform placed on the knife edge and weight suspended, absolute value in degrees;

m_P is the mass of platform, in kilograms;

θ_P is the angle formed by the platform bottom surface and the horizontal surface with the platform placed on the knife edge and no weight suspended, absolute value in degrees;

z_P is the distance from the platform bottom surface to the centre of gravity along the z-axis, in millimetres;

h_0 is the distance from the platform bottom surface to the knife edge along the z-axis, in millimetres.



a) Measurement of θ_P

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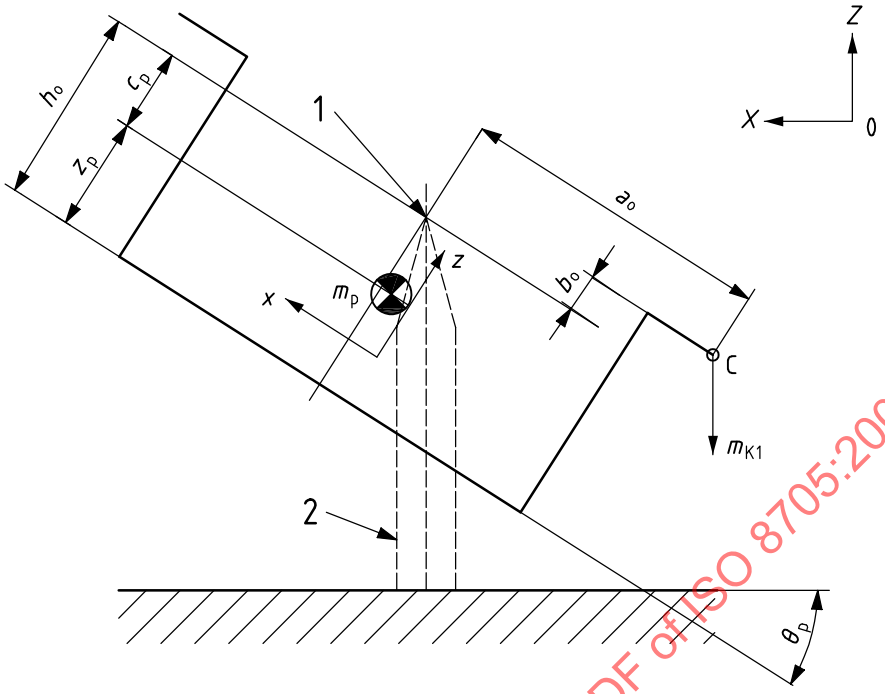

b) Measurement of θ_K

Key

1 knife edge

2 stay

Figure 5 — Location of centre of gravity of the platform along z-xis (point C side lower)

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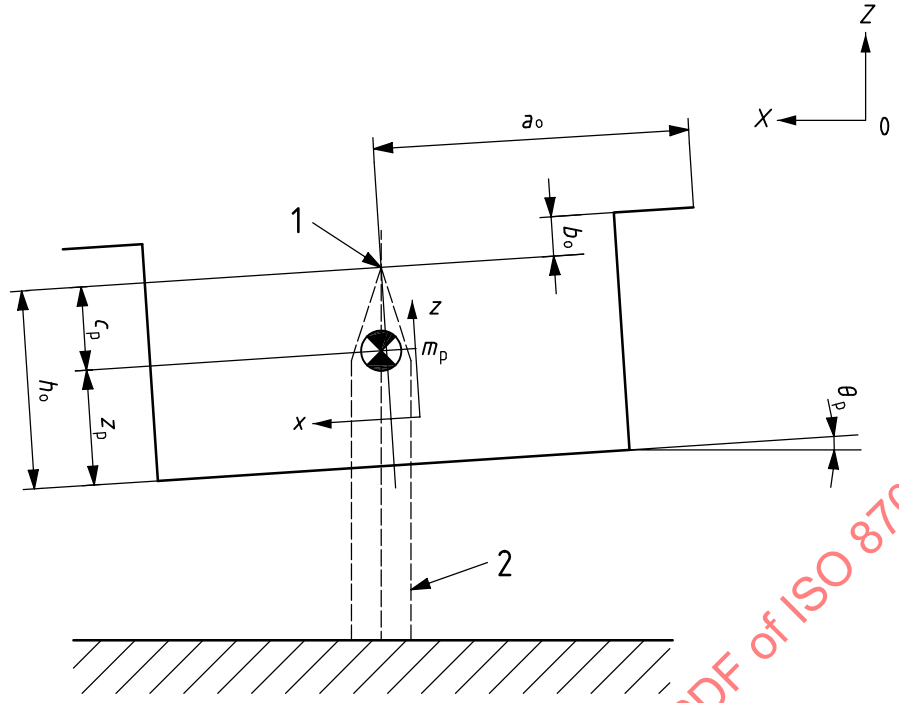
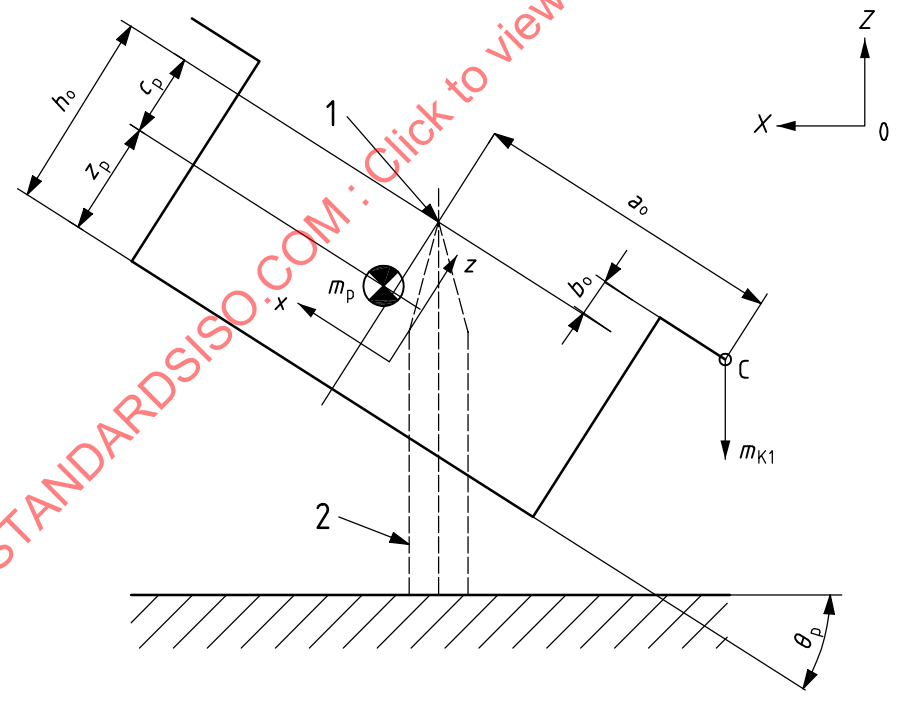


a) **Measurement of θ_P**



b) **Measurement of θ_K**

Key

1 knife edge

2 stay

Figure 6 — Location of centre of gravity of the platform along z-xis (point C side raised)

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6.3.2 Location of centre of gravity of the moped along z-axis

Measure the location of the centre of gravity of the moped [5)] along the z-axis as follows (see Figures 7 and 8):

a) place the moped on the platform and fix it so it cannot move; the lateral inclination angle of the moped to the platform shall be 0° ± 0,5°;

b) place the platform on the knife edge of the stay and measure the angle θ_T formed by the platform bottom surface and the horizontal surface; at this time, the calculation equation for the location of centre of gravity as described in e) varies depending on the platform inclination direction;

c) adjust the moped fixing position so that θ_T is as small as possible;

d) suspend a weight of mass, m_{k2}, from point C of the platform and measure the angle, θ_{TK}, formed by the platform bottom surface and the horizontal surface [see Figures 7b) and 8b)]; as the inclination angle, θ_{TK}, increases, the value of the location of centre of gravity along the z-axis becomes stable and the measurement error decreases.

NOTE It is recommended to incline it more than 10°.

e) calculate the distance, z_g, from the surface where the front and rear wheels of the moped touch the ground to the centre of gravity along the z-axis using the following equations; for the ± symbols in the equation, use the negative if the point C side is lower when measuring θ_T [see Figure 7a)] and use the positive when the point C side is raised [see Figure 8a)]:

$$m_T = m_P + m_{k2} + m_m \tag{21}$$

$$c_T = \frac{m_{k2}\left(a_0 + b_0 \tan\theta_{TK}\right)}{\left(m_P + m_m\right)\left(\tan\theta_{TK} \pm \tan\theta_T\right)} \tag{22}$$

$$c_m = \frac{m_T c_T + m_{k2} b_0 - m_P c_P}{m_m} \tag{23}$$

$$z_g = h_0 - c_m \tag{24}$$

where

m_T is the total platform, weight and moped mass, in kilograms;

m_{k2} is the mass of the weight suspended from the platform, in kilograms;

m_m is the mass of the moped, in kilograms;

c_T is the distance from the knife edge to the centre of gravity of both platform and moped along the z-axis, in millimetres;

θ_{TK} is the angle formed by the platform bottom surface and the horizontal surface with the platform placed on the knife edge and weight suspended, absolute value in degrees;

θ_T is the angle formed by the platform bottom surface and the horizontal surface with the platform placed on the knife edge and no weight suspended, absolute value in degrees;

c_m is the distance from the knife edge to the centre of gravity of the moped along the z-axis, in millimetres;

z_g is the distance from the surface where the front and rear wheels of the moped touch the ground to the centre of gravity along the z-axis, in millimetres;

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